A Model of Habitability Within the Milky Way Galaxy

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We present a model of the Galactic Habitable Zone (GHZ), described in terms of the spatial and temporal dimensions of the Galaxy that may favour the development of complex life. The Milky Way galaxy is modelled using a computational approach by populating stars and their planetary systems on an individual basis using Monte-Carlo methods. We begin with well-established properties of the disk of the Milky Way, such as the stellar number density distribution, the initial mass function, the star formation history, and the metallicity gradient as a function of radial position and time. We vary some of these properties, creating four models to test the sensitivity of our assumptions. To assess habitability on the Galactic scale, we model supernova rates, planet formation, and the time required for complex life to evolve. Our study improves on other literature on the GHZ by populating stars on an individual basis and by modelling SNII and SNIa sterilizations by selecting their progenitors from within this preexisting stellar population. Furthermore, we consider habitability on tidally locked and non-tidally locked planets separately, and study habitability as a function of height above and below the Galactic midplane. In the model that most accurately reproduces the properties of the Galaxy, the results indicate that an individual SNIa is ~5.6 \times more lethal than an individual SNII on average. In addition, we predict that ~1.2% of all stars host a planet that may have been capable of supporting complex life at some point in the history of the Galaxy. Of those stars with a habitable planet, ~75% of planets are predicted to be in a tidally locked configuration with their host star. The majority of these planets that may support complex life are found towards the inner Galaxy, distributed within, and significantly above and below, the Galactic midplane.

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